Biomass Modeling in the O^bjECTS Framework

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Outline

This talk will describe biomass modeling at the Joint Global Change Research Institute (JGCRI)

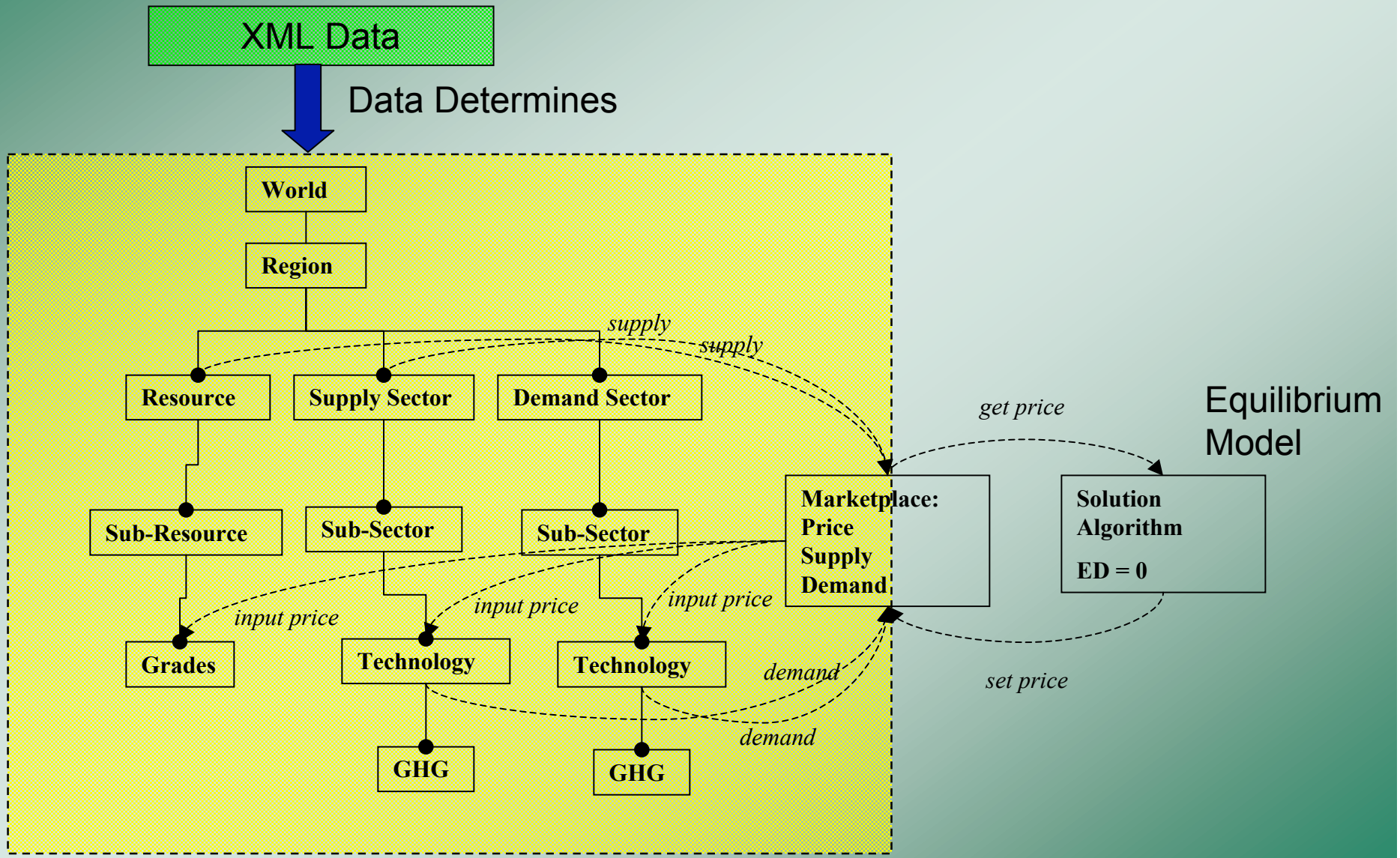
- The O^bjECTS Framework
  - O^bjECTS 1.0 (MiniCAM)
- Biomass Supply
  - Residue & Biocrops
- Biomass Demand
  - Direct-End Use
  - Electric Generation
  - Feedstock
- USA Biomass Projections
- Conclusions

The O^bjECTS Framework

The Object-oriented Energy, Climate, and Technology Systems (O^bjECTS) Framework uses a modular, data-driven architecture to model energy (and soon agricultural) systems.

- Implemented in C++
- eXtensible Markup Language (XML) data structures
- Arbitrary number of sectors and technologies
- Enables detail where needed
- Input data determines the market structure, sector definitions, fuels, and linkages.
- O^bjECTS 1.0 implements the MiniCAM model
  - Same partial-equilibrium equation structure
  - Substantially more flexibility in structure of the energy system

The ObjECTS Framework

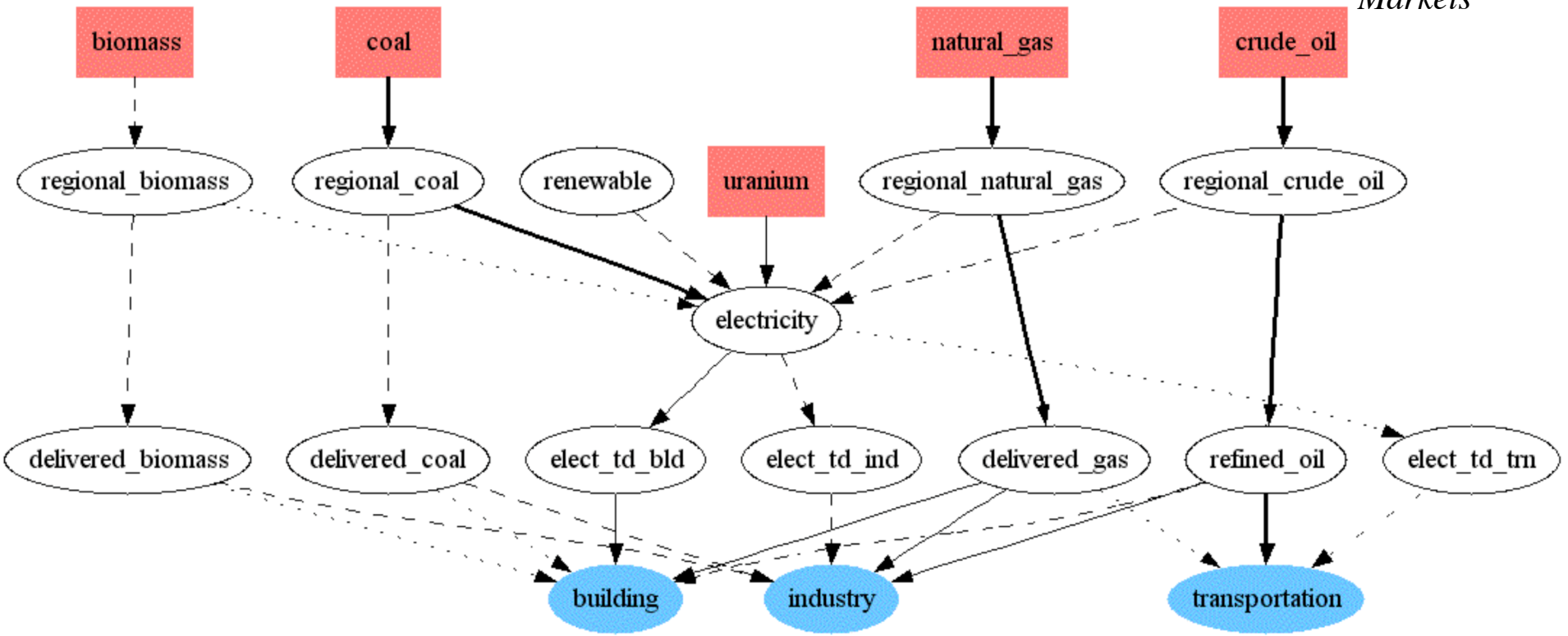


ObjECTS 1.0 Structure

The definition of "the" model is determined by the data more than the code.

1990 Energy System Structure

Data Determines:
Sectors
Linkages
Markets



Implemented for 14 World Regions

Biomass Supply

Two sources of biomass:

- Residue Streams
  - Wood chips, ag residues, urban wastes, etc.
  - Currently represented by aggregate, regional supply curve derived from EIA data (disaggregation planned)
- Biomass Crops
  - Composite biomass crop (disaggregation planned)
  - Produced by Agriculture & Land-Use Model (AgLU)

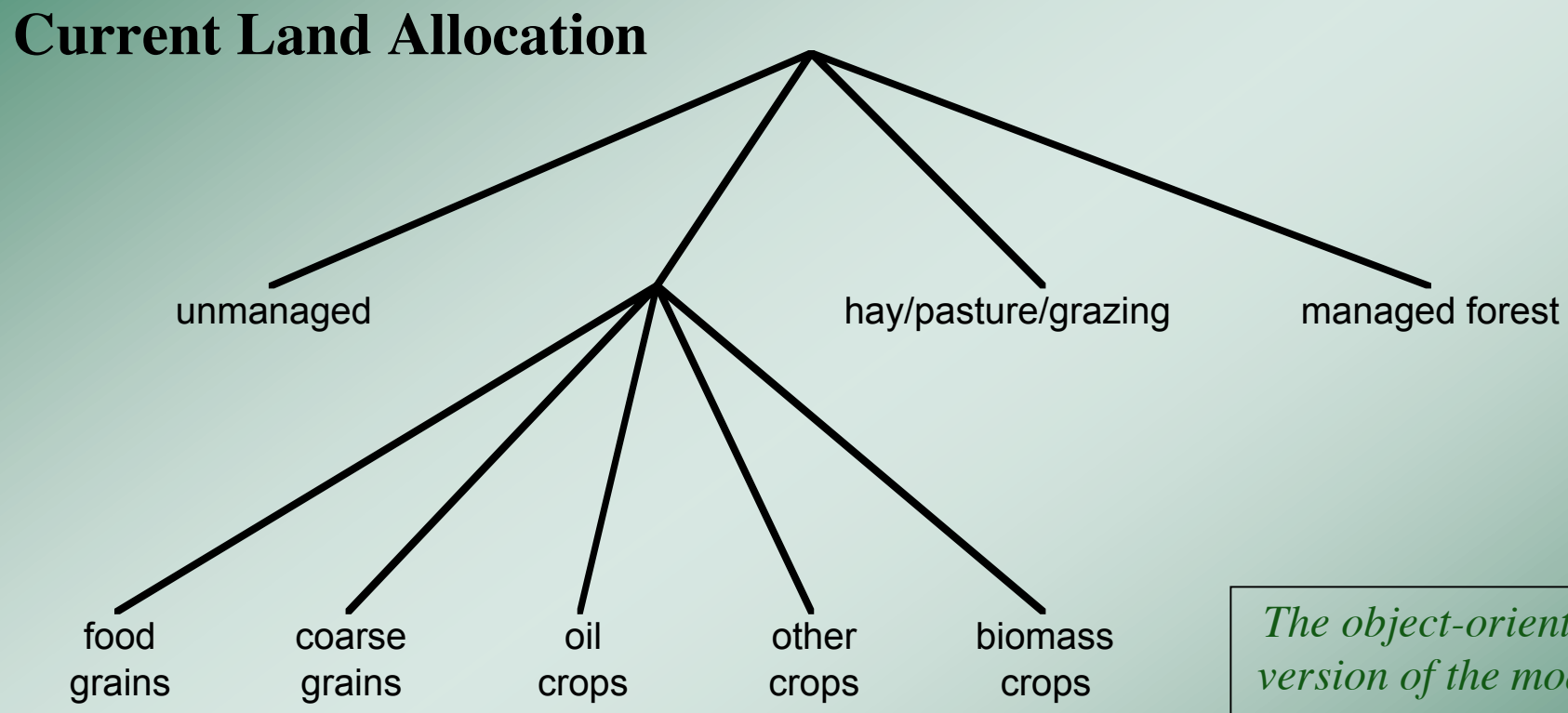
Regional or global biomass or biomass product markets can be configured

Agriculture and Land-Use (AgLU) Model

AgLU Characteristics (Sands and Leimbach 2003)

- Design
  - Top down
  - Partial equilibrium
- Land Allocation
  - Land owners compare economic returns across crops, biomass, pasture, and future trees
  - Underlying probability distribution of yields per hectare
- Forest Dynamics
  - Trees in AgLU grow for 45 years
  - Two forest markets (current and future) needed for model stability
- Status
  - Current procedural (FORTRAN) version is being converted to object-oriented architecture.

Agriculture and Land-Use Land Allocation



The object-oriented version of the model will enable more complex, data-driven, land allocation structures

Biomass Demand

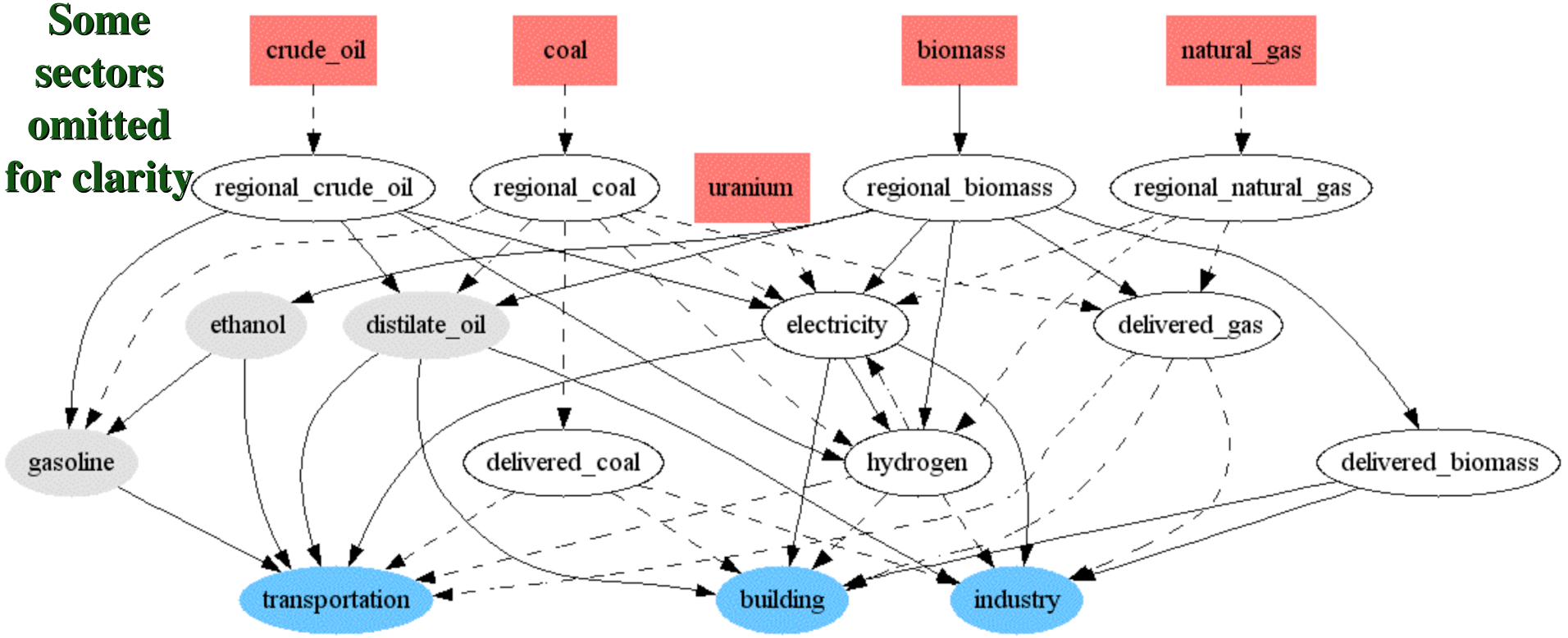
Biomass can be used in a number of ways

- Direct-End Uses
  - Industry heat (pulp&paper), buildings (traditional biomass, wood stoves)
- Electric Generation
  - Co-firing or dedicated plants
- Feedstock
  - Ethanol
  - BioDiesel (in progress)
  - Hydrogen
  - Syn Gas

Currently examining the appropriate disaggregation of biomass supply, transformation, and end use technologies.

ObjECTS 1.0 with ethanol

Model structure with refined liquids sectors and explicit ethanol production and use.



Illustrative Results: Ethanol Assumptions

Two sets of cases:

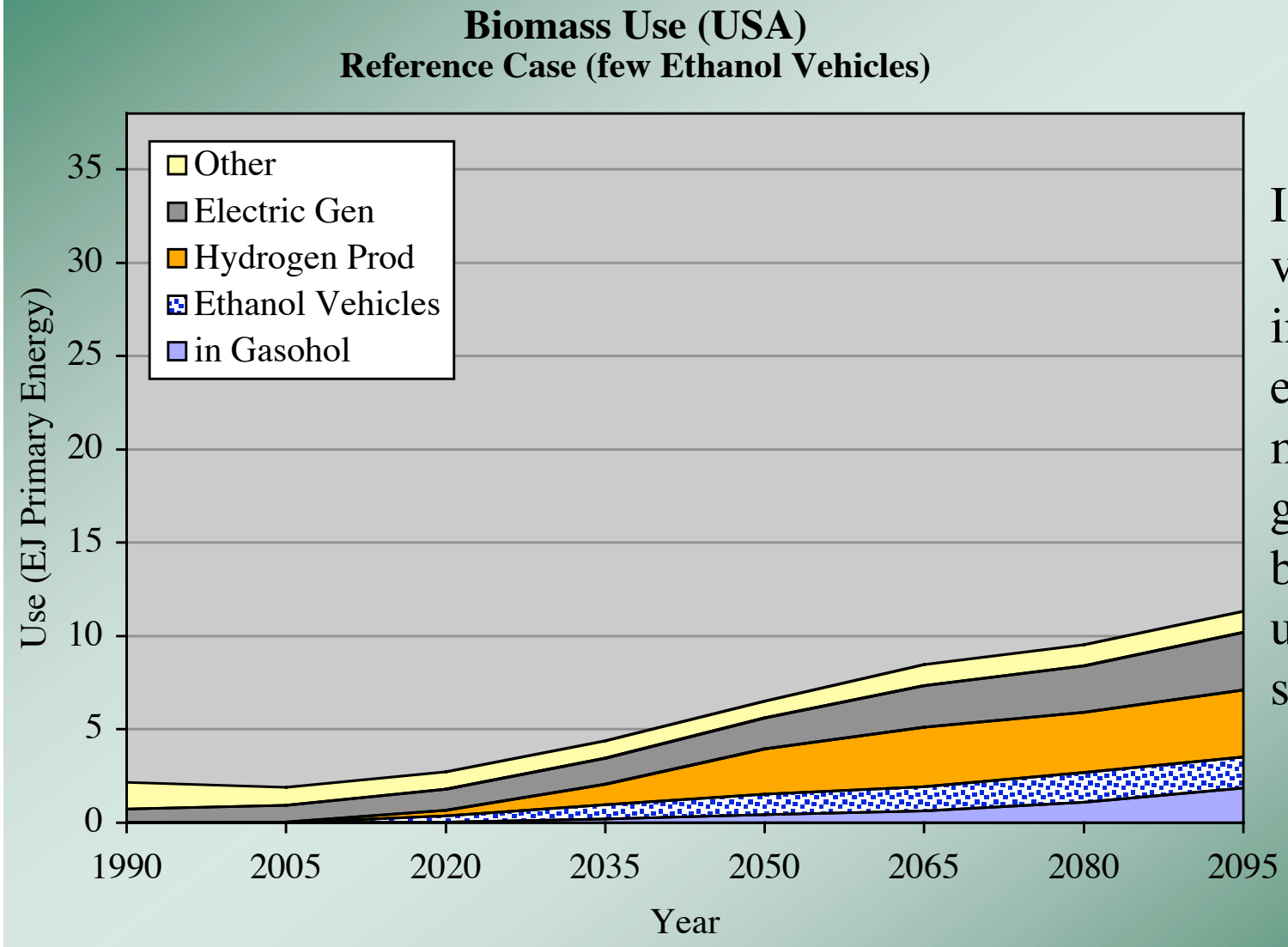
1) 100% ethanol vehicles are only available at a higher cost (which could be an opportunity cost), limiting them to niche markets.
2) 100% ethanol vehicles are available at only a slightly higher cost than gasoline-fueled vehicles.
    - This would require a dual-fuel infrastructure.

Ethanol production is assumed to occur via cellulosic conversion technologies

- Current corn->ethanol conversion, and its tax subsidy not included.
- Conservative case -- conversion cost is assumed to decline substantially, but still above current gasoline refining cost by 2100

Illustrative Results

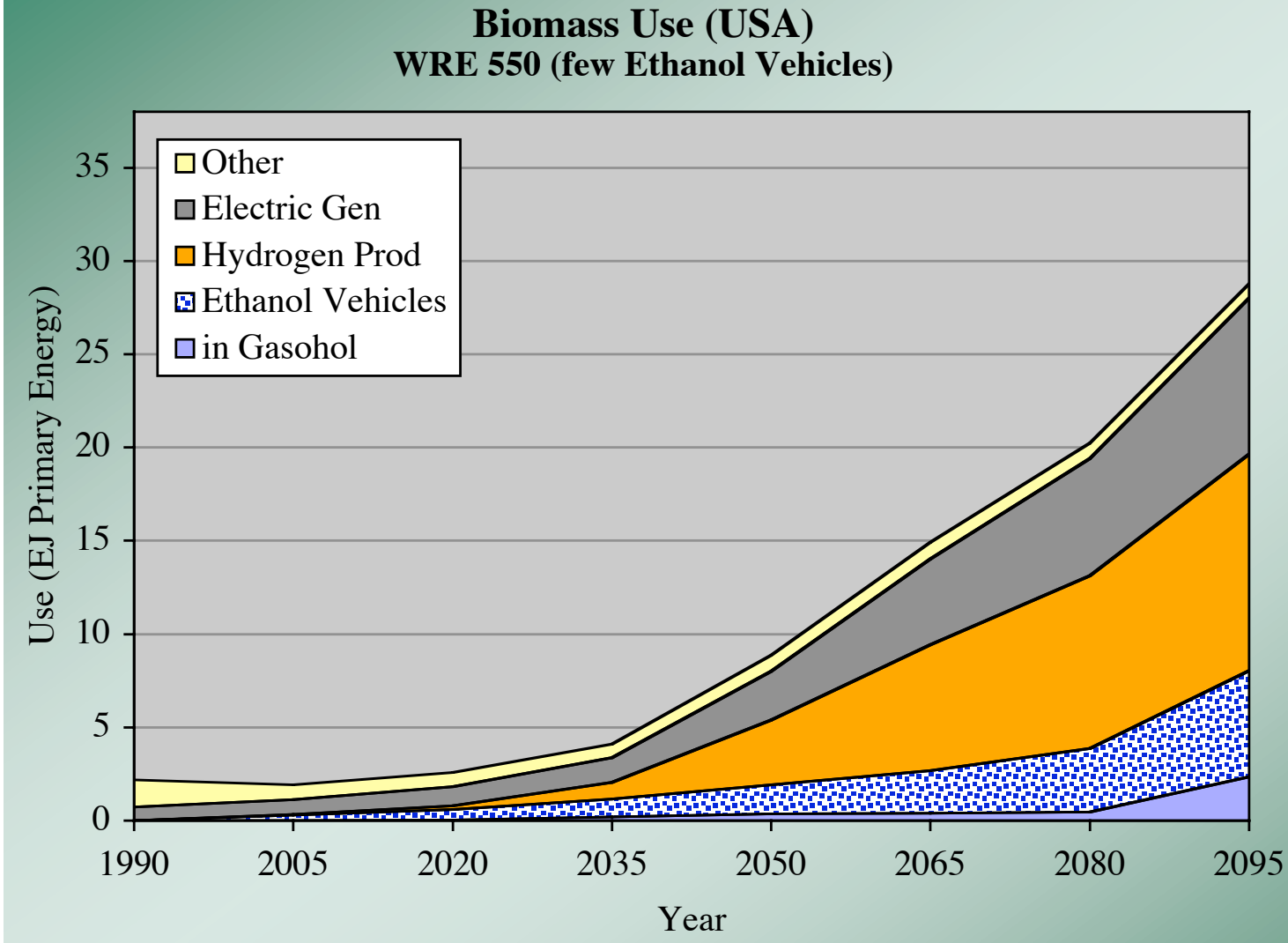
Reference Case - No Carbon Policy



If 100% ethanol vehicles are not in use, then ethanol is used mixed with gasoline, but biomass is also used in other sectors.

Illustrative Results

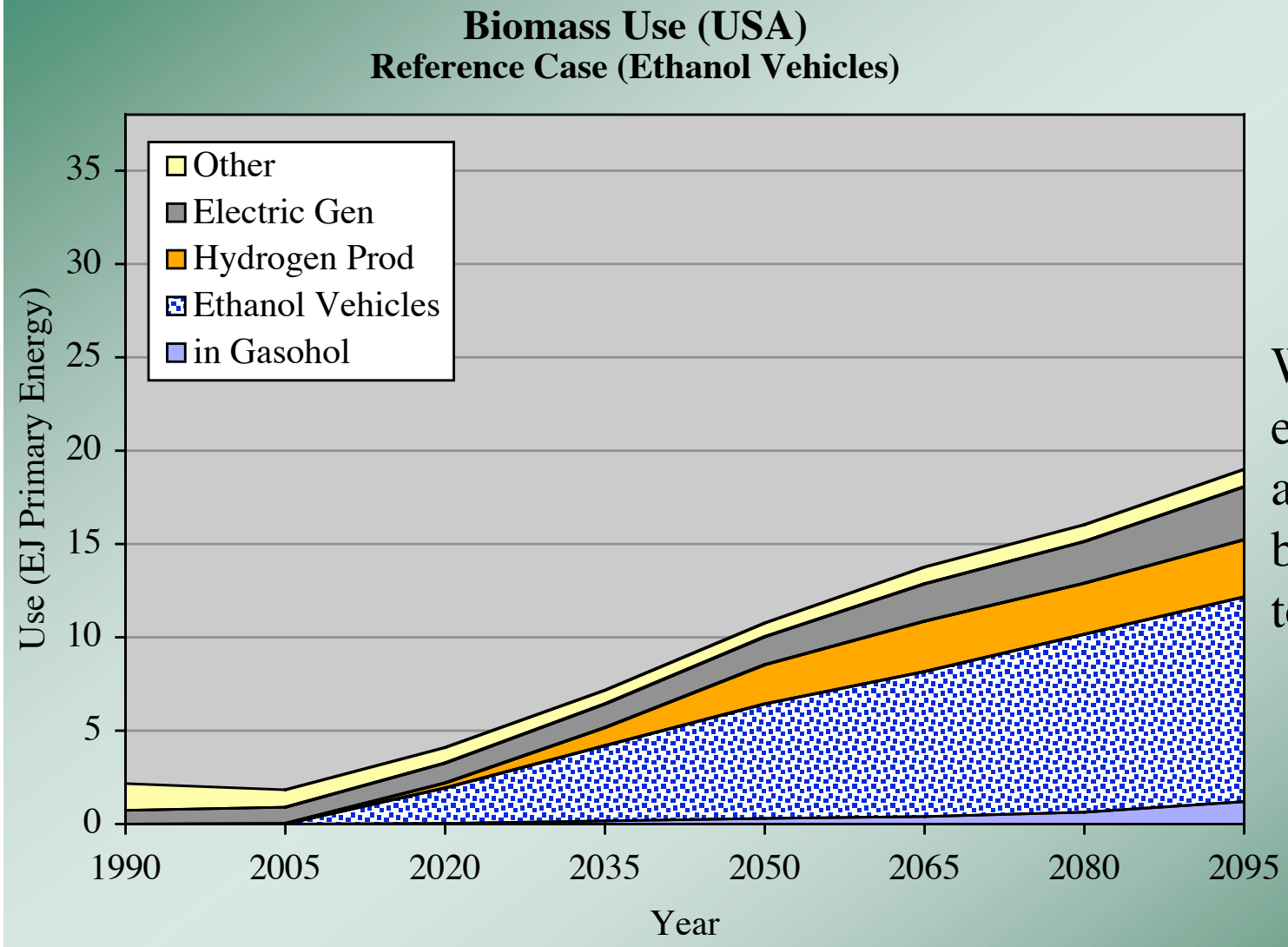
Policy Case - 550 ppmv Stabilization



In a stabilization case, if ethanol vehicles are not available at a cost similar to gasoline cars, then most biomass is used to generate H2 (assuming a demand exists) and electric generation

Illustrative Results (ethanol cars)

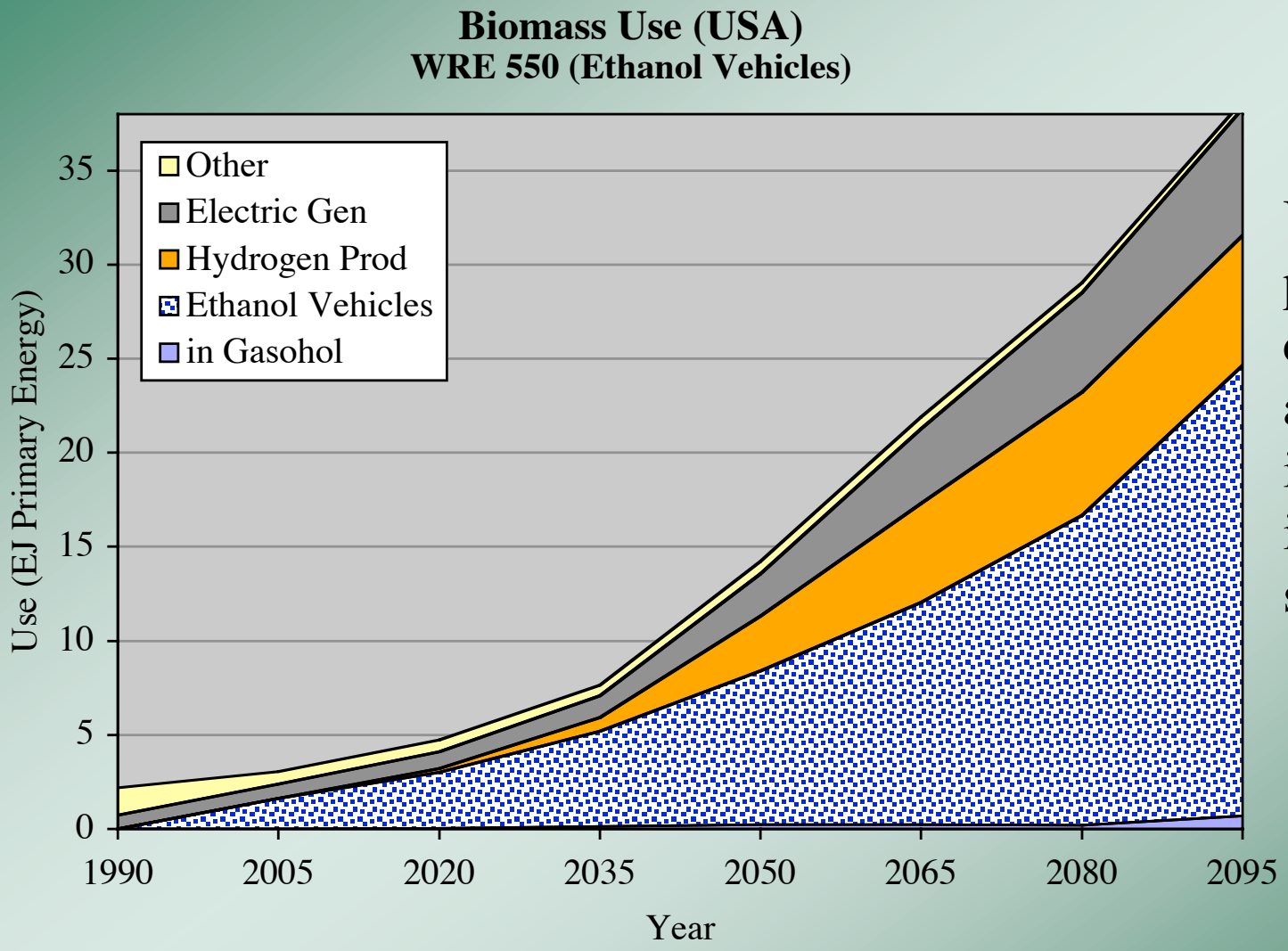
Reference Case - No Carbon Policy



With 100% ethanol vehicles available, most biomass is used to make ethanol.

Illustrative Results (ethanol cars)

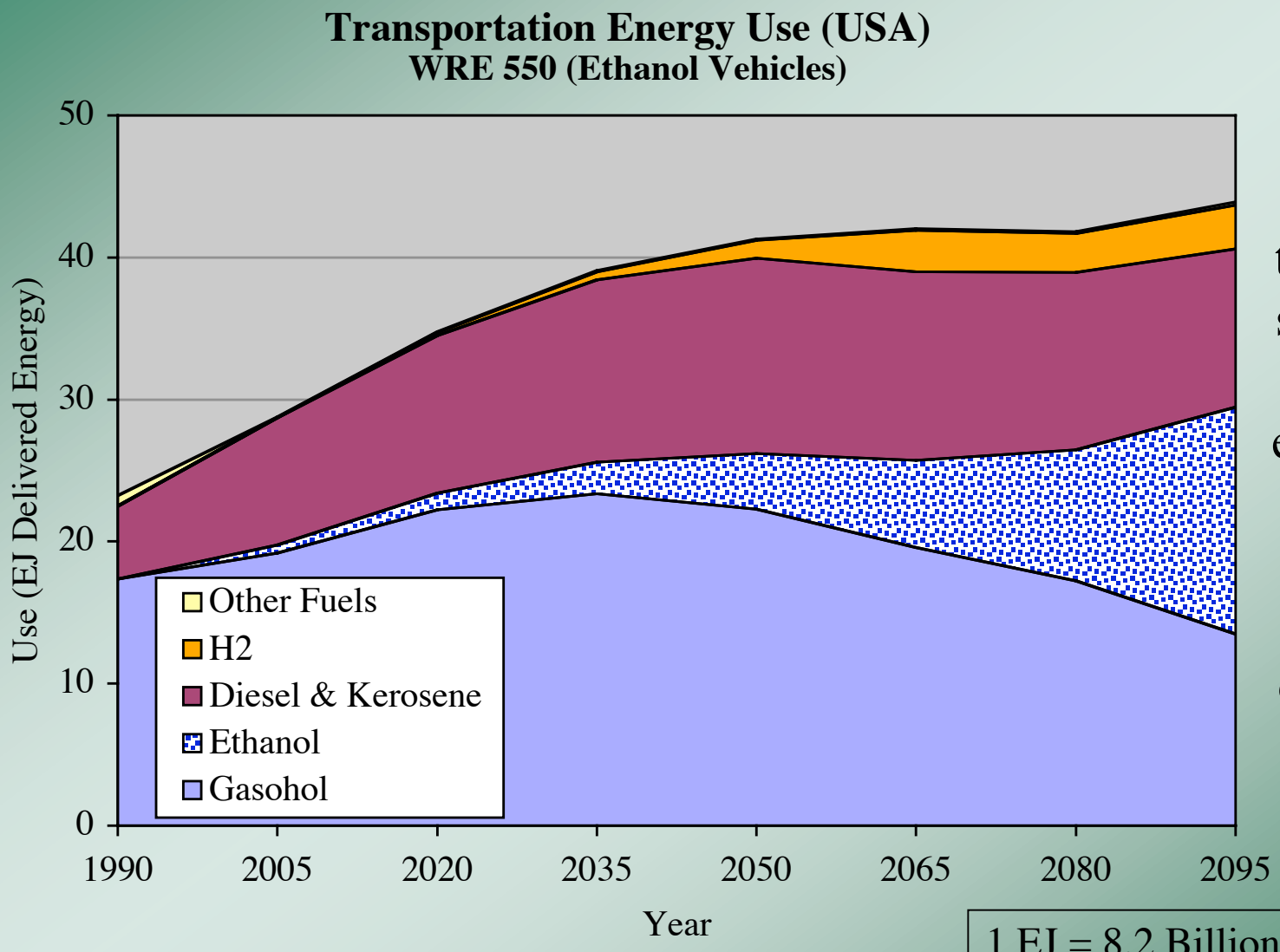
Policy Case - 550 ppmv Stabilization



Under a carbon policy biomass consumption, and ethanol use in particular, increases substantially.

Illustrative Results (ethanol cars)

Policy Case - 550 ppmv Stabilization



Most transportation is still powered by fossil fuels – even in a carbon policy case. Is such a system feasible or desirable? Is H_2 a better option?

1 EJ = 8.2 Billion Gallons Gasoline

Conclusions

- Biomass can be a significant contributor to the US energy system
  - If a demand for biofuels exists, then biomass is used preferentially as a feedstock, although other uses (co-firing, etc.) will still use biomass.
- Technology availability is a key assumption
  - The availability of end-use demands and associated infrastructure are key assumptions that determine how biomass is used.
- Ethanol has significant potential
  - If transportation demand exists (dual-fuel vehicles, etc.), ethanol could supply a large fraction of transportation demand by the end of the century
- Supply issues are very important
  - The total potential for biomass production is a key determinant of the future role of biomass, and the **key** determinant of total biomass use in a carbon policy scenario.

Work In Progress!

We will be further developing our biomass representation over the next few months and detailed results will likely change.